REMARKS

A petition for a one month extension of time has today been filed as a separate paper and a copy is attached hereto.

Responsive to the examiner's objection to the Abstract, as set forth in paragraph 1 of the final rejection, the Abstract has been amended as suggested by the examiner.

The rejection of claims 1, 6 and 13 for anticipation by U.S. 6,335,283 (Ngo et al) might be considered moot because claim 1 has been amended to include the limitation of claim 5.

Further, while Ngo et al '283 teaches the use of a nitrogen plasma (not an NH_3 plasma) to remove oxide from the copper lines (column 5, lines 59-65 and column 6, lines 7-10) it does not teach the subsequent step of nitriding the copper wiring to form a copper diffusion preventing layer. As taught in the previously noted passages of Ngo et al '283, simultaneous with cleaning of the Cu lines, the nitrogen plasma converts "the upper portion of the silicon oxide inter-layer dielectric between neighboring Cu lines to silicon oxynitride," quoting from column 5, lines 59-61. There is no teaching of nitriding of the copper itself to form a copper diffusion preventing layer as required by all pending claims. There is no barrier layer covering the Cu lines per se as is evident from the teaching at column 6, lines 43-48 which reads:

> A diffusion barrier or capping layer 50, such a silicon nitride, is then deposited in a conventional manner, as by plasma enhanced chemical vapor deposition, as shown in Fig. 4. The silicon nitride capping layer 50 covers the upper surfaces of the Cu lines 23 tightly adhering thereto by virtue of removing of the surface oxide layer 24 (Fig. 2).

The present invention nitrides the copper in order to obtain a copper diffusing layer and to avoid the approach of the prior art, e.g. Ngo et al '283, in applying silicon nitride as a diffusion barrier. As applicants teach at page 2, lines 6-12 of their original specification, the use of a silicon nitride film in the prior art creates problems in that it has a high dielectric constant and lowers the operation speed of the semiconductor device. As taught at page 3, lines 16-25 of applicants' original specification:

> The copper wiring layer itself has the function of preventing the diffusion of copper. Therefore, the high ability of preventing copper diffusion is not required for the copper diffusion preventing film (the block insulating film, etc.) formed on the copper wiring layer, etc. Therefore, there is no need to use the high dielectric films (SiN film and the like) of the prior art, which are considered to have a superior ability of preventing the copper diffusion.

Again, applicants' invention reforms the copper itself to produce a barrier to copper diffusion in order to avoid the need for a silicon nitride film. Further, when a via-hole is formed in the inner layer insulating film, the etching process is simplified because of the absence of a silicon nitride film.

Insofar as the rejection for claim 5 for obviousness over Ngo et al '283 in view of Islam et al might be considered applicable to claim 1 as amended, this rejection is also traversed for the

reason that neither Ngo et al '283 nor Islam et al suggests a combination of steps in succession including ammonia treatment to clean the copper surface followed by a plasma treatment of the copper to form a copper diffusion barrier. Note that Ngo et al '283 teaches that their nitrogen plasma step only serves to remove the surface oxide on the Cu lines. See column 5, lines 59-65 and column 6, lines 7-10 and 34-42. In view of the fact that the nitrogen plasma of Ngo et al '283 serves to clean copper oxide from the copper there would have been no motivation to add a second plasma treatment for that same purpose, e.g., the ammonia plasma treatment of Islam et al. The addition of the ammonia plasma cleaning step of Islam et al to the nitrogen plasma cleaning of Ngo et al '283 would have been considered redundant and nonsensical.

Further, like Ngo et al '283, Islam et al is completely silent with regard to any suggestion of reforming the copper itself to produce a copper diffusion barrier. Like Ngo et al '283, Islam et al form a copper barrier layer by plasma deposition of silicon oxynitride or silicon nitride. See column 4, lines 6-35 of Islam et al. Thus, both Ngo et al '283 and Islam et al form a copper diffusion barrier of a nature which represents the aforementioned problem of use of a high dielectric constant film as a copper diffusion barrier layer.

The rejection of claims 26 and 3 for anticipation by Smith et al '771 may also be considered moot in view of the incorporation of the limitation of claim 5 into claim 26.

The rejection of claim 4 for anticipation by Ngo et al '925 is likewise believed to be moot in view of the present amendment whereby the limitation of claim 13 has been incorporated into

claim 4. In this connection it should be noted that in rejecting claim 13 the examiner relied upon the teaching of Ngo et al '283 of formation of a SiN film over the copper layer. Ngo '283 does not disclose or suggest the formation of a SiOCH film over the copper.

The rejection of claim 7 for obviousness over Ngo et al '283 in view of Matsuda et al is traversed for the reason that claim 7 depends indirectly from claim 1 and neither Ngo et al '283 nor Matsuda et al suggest a combination of removal of oxide using an ammonia plasma followed by reforming of the copper itself to produce a diffusion barrier.

The rejection of claim 8 for obviousness over Ngo '283 in view of Islam et al is traversed for the reason that, as noted above, neither Ngo et al '283 nor Islam et al suggests a combination of steps in succession including ammonia treatment to clean the copper surface followed by a plasma treatment of the copper to form a copper diffusion barrier. Again, the addition of the ammonia plasma cleaning step of Islam et al would have been considered redundant.

The rejection of claim 12 for obviousness over Ngo et al '283 in view of Islam et al and Smith '733 is traversed for the same reason that the rejection of claim 8 is traversed above. Claim 12 depends from claim 8 and the additional citation of Smith '733 does not suggest use of both the ammonia plasma cleaning step of Islam et al and the nitrogen plasma cleaning step of Ngo et al '283 in succession, for the reasons stated above, e.g., redundancy.

Newly added claims 27 and 28 define the invention as a combination of steps including formation of a SiOC film, i.e., a film which does not contain nitrogen, over the copper wiring layer, a step not suggested by any reference of record.

In conclusion, it is respectfully requested that the examiner reconsider the rejections of record with a view toward allowance of the claims as amended.

Respectfully submitted,

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